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A Critical Checklist of the Ants of Mongolia (Hymenoptera: Formicidae)

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Abstract. Here we present a critical species list of the ants of Mongolia, that is based on current literature, previously unpublished taxonomic changes, the unpublished records of the zoological expeditions of Japanese-Mongolian and German-Mongolian teams in the years 1997, 1999 and 2003 and the results of a four year Polish-German-Mongolian cooperation. We report on 68 species of 17 genera of ants that have been found within Mongolia: *Camponotus*, *Cardiomyrmex*, *Cataglyphis*, *Crematogaster*, *Dolichoderus*, *Formica*, *Harpagoxenus*, *Lasius*, *Leptothorax*, *Messor*, *Myrmica*, *Plagiolepis*, *Polyergus*, *Proformica*, *Tapinoma*, *Tennothorax* and *Tetramorium*. Six species are new to Mongolia: *Formica presiliabris* Nylander, 1846, *Lasius gebaueri* Seifert, 1992, *Myrmica commarginata* Ruzsky, 1905, *Myrmica kamtschatica* Kupryanskaya, 1986, *Myrmica eidmanni* Menozzi, 1930 and *Myrmica taediosa* (Bolton, 1995).

Keywords. Asia, Mongolia, Formicidae, species list.

1. INTRODUCTION

Mongolia occupies several natural zones where the Siberian taiga forest meets the Central Asian steppe and the Gobi desert. Steep gradients of temperature and moisture show opposing trends and run contrary from North to South resulting in a vegetation sequence of forest, steppe, semi desert and desert that is considerably influenced by different soil conditions and altitudinal changes. This complex set of parameters, together with the large area of the country, creates a large variety of habitats and has a distinct influence on the biodiversity of the region (EMELJANOV & KERZHNER 1983; WALTER 1983; BRECKLE et al. 1994). Ants are a dominant part of the ground-dwelling Mongolian entomofauna, and form distinct communities in the different biomes and vegetation zones of this country (PFEIFFER et al. 2003).

The ant fauna of Central Asia has been studied for more than a century (e.g., MOCSÁRY & SZÉPLIGETI 1901), however, either these early expeditions did not occur on the territory of today's Mongolia (RUZSKY 1905; STITZ 1934; YASUMATSU 1940), or other authors had caste doubt on the validity of the determinations (e.g., DLUSSKY 1965 on RUZSKY 1915, and PISARSKI 1969a on FOREL 1904 and MOCSÁRY & SZÉPLIGETI 1901). Basic information on the

Mongolian ant fauna has been gathered by the Hungarian entomologist Dr. Z. KASZAB, whose collections from the 1960s were identified by DLUSSKY (1965), DLUSSKY & PISARSKI (1970), PISARSKI (1969 a,b) and PISARSKI & KRZYSZTOFIAK (1981). DLUSSKY (1964, 1967, 1969), RADCHENKO (1994b,c, 1995a, 1997a, 2005) and SEIFERT (2000, 2003, 2004) provided additional information on the ant species composition of the Mongolian fauna and were focused to the taxonomic editing of the species (for details see below). PFEIFFER et al. (2003, 2004) obtained the first ecological research data that revealed the biogeographical patterns of the Mongolian ant fauna. Here we present a preliminary checklist of the ants of Mongolia based on a critical evaluation of older literature and on the results of our own expeditions.

2. MATERIALS AND METHODS

Our study is based on altogether 2145 samples from 174 locations that were accumulated in Mongolia between 1997 and 2004 (Fig. 1). We collected ant specimens during several expeditions to the Gobi desert and the steppe and forest zones of this country. Additionally several hundred specimens of other collections were taxonomically evaluated by A. Radchenko and B. Seifert.

Three German Mongolian expeditions were conducted by M. Pfeiffer and K. Ulykpan: the first together with L. Chimedregdzcn from July to September 1997, the second in July/August 1999 and the third together with A. Ulykpan in July/August 2003. They collected 703 samples mostly from baits at 67 locations in 1997 and 1999, including 11 sites that have been sampled most intensively (see PFEIFFER et al. 2003), and about 200 samples of a larger investigation at altogether 37 locations in 2003. All specimens were collected from several North-South transects between E95° and E118° longitude all over Mongolia. M. Woyciechowski collected 262 samples from *Myrmica* nests within four years (1999, 2000, 2001, and 2002) in the forest steppe zone in the Hentii region (North Mongolia). Ants from nests were collected in all types of vegetation (MÜHLENBERG et al. 2000) around and between three main locations stretched across ca 100 km along the 49th parallel: Honin Nuga Research Station (N49°04'48", E107°17'15"), Hot springs (N49°01'08", E107°32'43") and Ming River valley (N49°00'06", E108°02'36"). The

Japanese-Mongolian expedition of Sk. Yamane and A. Ulykpan accumulated 2200 ant specimens from 233 samples from colonies and general collection that were sampled in June and July 2003, in Bogd Han National Park, Hustai N.P., and Terelj N.P. (all Tuv aimag); in Zamyn uud (Dornogovi aimag) and in July 2004 in Bogd Han N.P.; in Honin Nuga, and in Han Hentii Mts. (Selenge aimag). R. Schultz sampled the western part of Mongolia in July and August 2003 on an expedition from Ulaanbaatar through Hangai Mts. to Hovd and the Mongolian Altai (Hovd aimag) and examined 255 nest samples collected from 47 sites. He added more data to our list by the evaluation of 1) the collection of the University of Halle (77 samples from 7 locations), which was mainly due to the work of Mrs. Dr. A. Stubbe and 2) of the diploma thesis of A.-L. Lucau (2004), who collected 145 samples of the same three sites that had also been collected by M. Woyciechowski (Honin Nuga Research Station, Hot springs and Ming River valley) and was supervised by Prof. Dr. M. Mühlenberg, University of Göttingen.



Fig. 1. Map of Mongolia. Given are the positions of our sample sites. The world map in the upper right corner shows the geographical position of Mongolia (black) in the centre of Asia.

If not explicitly stated otherwise, the material that we have collected during these journeys was identified by Alexander Radchenko (genera *Camponotus*, *Cataglyphis*, *Crematogaster*, *Messor*, *Myrmica*, *Plagiolepis*, *Proformica* and *Temnothorax*), Bernhard Seifert (genera *Cardiocondyla*, *Formica*, *Lasius* and *Polyergus*), Graham-W. Elmes (*Myrmica*) and the other authors. Collection details and localities for all species will be given in future publications, in which we plan to map the distribution patterns of the main species.

To compile the species list we compared our data with that in the literature (see Table 1 and references). These references were critically scrutinized by our taxonomic experts (B. Seifert, A. Radchenko) and the validity of the nomenclature was checked by evaluating the latest taxonomic publications (BOLTON 1995, 2003; RADCHENKO 1994a,b, 1995b,c, 1997a,b; RADCHENKO et al. 2002; SEIFERT 1992, 2000, 2003, 2004).

3. RESULTS

The resulting list of the Mongolian fauna comprises 68 species of ants of 17 genera (Table 1). After cross checking of literature we conclude that six species are new to the Mongolian fauna (R. Schultz, Sk. Yamane & M. Woyciechowski, unpubl. results):

Formica pressilabris Nylander, 1846

Hangai mountain region, Arhangai aimag (province), Tsetserleg soum, ca. 12 km west of Tsetserleg, 1886 m, leg. R. Schultz, 02.08.2003, det. B. Seifert.

Lasius gebaneri Seifert, 1992

Tuv aimag: Bogd Han N.P., 1550 m, leg. Sk. Yamane, 27.06.2003, det. B. Seifert.

Mongolian Altay, Hovd aimag, ca. 8 km south of Hovd, ca. 20 km west of Hovd, 2021 m, leg. R. Schultz, 08.08.2003, det. B. Seifert.

Myrmica commarginata Ruzsky, 1905

Hovd aimag, Durgun soum, Chonoharaihiin gol, Derris, 1154 m, leg. A. Stubbe, 27.08.2003, det. R. Schultz & A. Radchenko.

Myrmica eidmanni Menozzi, 1930

Selenge aimag, western Han Hentii Mts, 3 km SW from Honin Nuga Research Station, near Eruu River (N49°03.81', E107°16.14'), 930 m, 06.08.1999 and 8 km E from Honin Nuga Research Station, near Sharlan River (N48°57.70', E107°04.26'), 970 m, 23.07.2000, both leg. M. Woyciechowski, det. G. W. Elmes & A. Radchenko.

Selenge aimag, western Han Hentii Mts, Sharlan River, near Honin Nuga research station, 1000 m, leg. A.-L. Luceau, July 2001, det. A. Radchenko.

Selenge aimag, western Han Hentii Mts, Sharlan River, near Honin Nuga research station, leg. Sk. Yamane, July 2004, det. Sk. Yamane.

Myrmica kaantschatica Kupyanskaya, 1986

Selenge aimag, western Han Hentii Mts, 8 km E from Honin Nuga Research Station, near Sharlan River (N48°57.70', E107°04.26'), 970 m, leg. M. Woyciechowski, 23.07.2000 and the same location on 6.07.2001, det. G. W. Elmes & A. Radchenko.

Myrmica taediosa (Bolton, 1995)

Selenge aimag, western Han Hentii Mts, 9 km SW from Honin Nuga Research Station, near Eruu River (N49°02.39', E107°11.62'), 1045 m, leg. M. Woyciechowski, 28.07.2002, det. G. W. Elmes & A. Radchenko.

Due to taxonomic changes and to our critical evaluation of the species lists that have been previously published, this first comprehensive list of the Mongolian ant fauna contains a changed species spectrum compared to the older literature. For example *Lasius alienus* (Förster, 1850) has been reported from Mongolia in four publications (DLUSSKY & PISARSKI 1970; PISARSKI 1969a,b; PISARSKI & KRZYSZTOFIK 1981), however, regarding to SEIFERT (1992), this species is constricted to Europe, so the taxonomic position of these samples was doubtful. A rechecking of these specimens that had been collected by Kaszab and are housed in the Hungarian National Museum showed that they were most possibly specimens of *Lasius cf. obscuratus*, but definitely not of *Lasius alienus* (Sándor Csösz, Budapest, pers. comm. 2005). *Lasius cf. obscuratus* has been also sampled by PFEIFFER (2003) but due to the low number of specimens this determination is still uncertain and needs to be confirmed.

Other records that have been previously published are also uncertain and may be a result of misidentifications (unpublished results A. Radchenko): e.g., *Camponotus herculeanus herculeanus* Linnaeus, 1758 (in DLUSSKY & PISARSKI 1970), *Cardiocondyla staudouffi* Forel, 1892 (in PISARSKI 1969b; PISARSKI & KRZYSZTOFIK 1981, but see RADCHENKO 1995c and SEIFERT 2003), *Myrmica bergi* Ruzsky 1902 that was confirmed to be *Myrmica divergens* Karavaiev, 1931 (in PFEIFFER et al. 2003, but see RADCHENKO et al. 2002), *Myrmica saposchukovi* Ruzsky, 1903 (in PISARSKI 1969a,b, PISARSKI & KRZYSZTOFIK 1981), that was proved to be *M. pisarskii* Radchenko, 1994 (see RADCHENKO 1994b, 1995b), and *Myrmica schencki* Viereck, 1903 (in PISARSKI & KRZYSZTOFIK 1981), which

Table 1. A critical list of the ant species that have been found in Mongolia, according to literature, to our expeditions and the expertise of our taxonomic experts A. Radchenko and B. Seifert. a = STITZ (1934), b = HOLGERSEN (1943), c = DLUSSKY & PISARKI (1970), d = DLUSSKY 1965, e = PISARSKI (1969a), f = PISARSKI (1969b), g = PISARSKI & KRZYSZTOFIAK (1981), h = RADCHENKO (1994b), j = RADCHENKO (1994c), k = RADCHENKO (1995a), l = BOLTON (1995), m = German-Mongolian expedition 1997; 1999 (collection M. Pfeiffer, unpublished), n = collection of Kawaguchi, o = Radchenko (1997a), p = Dubatolov (1998), q = collection of M. Woyciechowski (1999–2004), r = collection of R. Schultz (leg. A.-L. Luau 2001, 2003), s = collection of R. Schultz (leg. University of Halle, Germany), t = Imai et al. (2003), u = Pfeiffer et al. (2003), v = German-Mongolian expedition 2003 (M. Pfeiffer), w = German-Mongolian expedition 2003 (R. Schultz), x = SEIFERT 2003, y = Japanese-Mongolian expedition 2003 (Sk. Yamane), z = Japanese-Mongolian expedition 2004 (Sk. Yamane), 1 = SEIFERT (2004), 2 = RADCHENKO (2005), 3 = Personal collection A. Ulykpan. Valid scientific names were obtained from BOLTON 1995, 2003; RADCHENKO 1994 a,b, 1995b,c, 1997 a,b; RADCHENKO et al. 2002 and SEIFERT 2000, 2003, 2004.

Scientific name	References
<i>Camponotus japonicus</i> Mayr, 1866	b,c,c,f,g,s,y,z,3
<i>Camponotus herculeanus sachalinensis</i> Forel, 1904	c,e,f,g,w,y,z,3
<i>Camponotus saxatilis</i> Ruzsky, 1895	m,o,w,z,
<i>Camponotus turkestanus</i> André, 1882	f,g,s,u,v
<i>Cardiocaudyla koshewnikovi</i> Ruzsky, 1902	u,w,x
<i>Cataglyphis aeonescens</i> (Nylander, 1849)	c,e,f,g,s,u,v,w
<i>Crematogaster subdentata</i> Mayr, 1877	g,u
<i>Dolichoderus sibiricus</i> Emery, 1889	2
<i>Formica aquilonia</i> Yarrow, 1955	c,n,v,y, z
<i>Formica candida</i> Smith, 1878	c,d,e,f,g,n,r,s,u,v,w,y,z,1,3,
<i>Formica clara</i> Forel, 1886	c,f,u,v,y
<i>Formica clarissima</i> Emery, 1925	s,u,w
<i>Formica cunicularia</i> Latreille, 1798	c,f,g,3
<i>Formica exsecta</i> Nylander, 1846	d,m,w,y,z
<i>Formica forsslundi</i> Lohmander, 1949	c,e,f,g,w,3
<i>Formica japonica</i> Motschoulsky, 1866	t
<i>Formica kozlovi</i> Dlussky, 1965	d,e,f,g,m,w,y,3
<i>Formica lemani</i> Bondroit, 1917	c,d,f,g,m,w,y,z,3
<i>Formica lugubris</i> Zetterstedt, 1838	f,w,y z,
<i>Formica manchu</i> Wheeler, 1929	c,d,e,f,g,l,m,n,s,w,y,z,3
<i>Formica pisarskii</i> Dlussky, 1964	d,e,f,g,v,w,y,3
<i>Formica pratensis</i> Retzius, 1783	c,d,f,s,3
<i>Formica pressilabris</i> Nylander, 1846	w
<i>Formica sanguinea</i> Latreille, 1798	c,d,e,f,g,s,u,y,z,3
<i>Formica truncorum</i> Fabricius, 1804	c,d,f,3
<i>Formica uraleensis</i> Ruzsky, 1895	c,d,e,f,g,u,w,y,3
<i>Harpagoxenus zaisanicus</i> Pisarski, 1963 ¹	c,f,g,3
<i>Lasius distinguendus</i> (Emery, 1916)	e,f,3
<i>Lasius flavus</i> (Fabricius, 1781)	b
<i>Lasius gebaueri</i> Seifert, 1992	w,y,z,3
<i>Lasius niger</i> (Linnaeus, 1758)	b,c,f,g
<i>Lasius przewalskii</i> Ruzsky, 1915	g,w,y,z,3
<i>Leptothorax acervorum</i> (Fabricius, 1793)	e,f,g,w,3
<i>Leptothorax muscorum</i> (Nylander, 1846)	c,e,f,g,y,3
<i>Messor aciculatus</i> (Smith, 1874)	e,f,u,y
<i>Messor excursionis</i> Ruzsky, 1905	g
<i>Myrmica augulitoides</i> Ruzsky, 1905	c,e,f,g,r,w,q,y,z,3
<i>Myrmica arnoldii</i> Dlussky, 1963	c,e,g,r,q,y,z,3
<i>Myrmica commarginata</i> Ruzsky, 1905	s
<i>Myrmica divergens</i> Karavaiev, 1931	c,e,g,w,q,y,z,3
<i>Myrmica eidmanni</i> Menozzi, 1930	q,r,z

<i>Myrmica forcipata</i> Karavaiev, 1931	e,f,g,r,w,q,3
<i>Myrmica kamtschatica</i> Kupyanskaya, 1986	q
<i>Myrmica kasczenkoi</i> Ruzsky, 1905	c,e,f,g,v,w,y,3
<i>Myrmica koreana</i> Elmes, Radchenko & Kim 2001	u,q
<i>Myrmica pisarskii</i> Radchenko, 1994	h,s,u,w,q,y,3
<i>Myrmica rubra</i> (Linnaeus, 1758)	b,k
<i>Myrmica ruginodis</i> Nylander, 1846	k,q
<i>Myrmica sulcinodis</i> Nylander, 1846	e,f,r,q,3
<i>Myrmica taediosa</i> Bolton, 1995	q
<i>Plagiolepis manczshurica</i> Ruzsky, 1905	e,f,g,u
<i>Polyergus nigerrimus</i> Marikovsky, 1963	p,u
<i>Proformica buddhaensis</i> Ruzsky, 1915	f,g,u
<i>Proformica coriacea</i> Kuznetsov-Ugamsky, 1927	f
<i>Proformica jacoti</i> (Wheeler, 1923)	g,w
<i>Proformica kaszabi</i> Dlussky, 1969	u
<i>Proformica mongolica</i> (Emery, 1901)	c,e,f,g,u,w
<i>Tapinoma orthocephalum</i> Stitz, 1934 ²	a
<i>Tapinoma sinense</i> Emery, 1925	j
<i>Tennothorax kaszabi</i> (Pisarski, 1969)	f,g,3
<i>Tennothorax melleus</i> (Forel, 1904)	f
<i>Tennothorax mongolicus</i> (Pisarski, 1969)	f,u,v,z
<i>Tennothorax nassonowi</i> (Ruzsky, 1895)	e,f,g,u,y
<i>Tennothorax servicus</i> (Ruzsky, 1902)	c,e
<i>Tetramorium armatum</i> Santschi, 1927	g,u
<i>Tetramorium concaviceps</i> Bursakov, 1984	u
<i>Tetramorium inerme</i> Mayr, 1877	f,u
<i>Tetramorium tsushimae</i> Emery, 1925	c,e,f,g,u,w,y

¹ This species is on the red list of Mongolia ([http://www.r RDDlist.org](http://www.rッドlist.org)).

² This species has been reported from South Mongolia, but it is unclear whether this place is now in the Peoples Republic of China.

in fact is *M. koreana* Elmes, Radchenko & Kim 2001. Other mistakes seem to be most probably *T. caespitum* Linnaeus, 1758 (in DLUSSKY & PISARSKI 1970; PISARSKI 1969b), that may be *Tetramorium tsushimae* Emery, 1925 and also *Tetramorium ferox* Ruzsky, 1903 (in PISARSKI & KRZYSZTOFIAK 1981). Similarly, DLUSSKY & PISARSKI (1970) and PISARSKI (1969b) reported about *Formica polycetena* Förster, 1850 to occur in Mongolia's forest steppe, however, this seems to be a misidentification of specimens of *Formica aquilonia* Yarrow, 1955 (B. Seifert, pers. obs.). Because of the cold winter the occurrence of *F. polycetena* within Mongolia should be impossible. We excluded all suspicious records from our species list.

Due to the failure to access type material of *Formica subpilosa ruzskyi* Dlussky 1965, only indirect assessment of the status of this taxon is possible. Most certainly this taxon is conspecific with *F. clarissima* Emery, 1925 because any material known from Mongolia and Tibet seems to belong to one and the same species according to structur-

al characters. Furthermore there is no indication that those pigmentation characters proposed by the DLUSSKY (1965) for the differentiation of the *Formica subpilosa* subspecies *pamirica* Dlussky 1965, *clarissima* Emery 1925 (to which Dlussky applied the unnecessary replacement name *ruzskyi* Dlussky 1965) or *litoralis* Kuznetsov-Ugamsky 1926 could have any practical value. However, structural characters such as body morphometrics or setae counts computed in a discriminant analysis allow the separation of four Asian allospecies *Formica subpilosa* Ruzsky 1902, *F. clarissima* Emery 1925, *F. litoralis* Kuznetsov-Ugamsky 1926 and *F. pamirica* Dlussky 1965 (B. Seifert, unpubl. data). According to the material investigated by us only *F. clarissima* Emery 1925 could be confirmed for Mongolia. The possible occurrence of *F. subpilosa* in semideserts of S Mongolia, as extension of the population from Chinese Gobi desert, should be checked during further field studies. Similarly *Cataglyphis aenescens roickingeri* and *C. aenescens tankrei* have been synonymized with *C. aenescens* (Nylander, 1846) (RADCHENKO 1997b).

Table 2. Valid names of Mongolian ants and their former names or junior synonymies that have been used in the older literature.

Valid name	Former name
<i>Cataglyphis aenescens</i> (Nylander, 1846)	<i>Cataglyphis aenescens roickingeri</i> For <i>C. aenescens tankrei</i> For <i>F. longiceps</i> Dlussky, 1964
<i>Formica manchii</i> Wheeler, 1929	
<i>F. dlusskyi</i> Bolton, 1995	
<i>Formica candida</i> Smith, 1878	
	<i>F. picea</i> Nylander, 1846, sensu DLUSSKY 1967; sensu DLUSSKY & PISARSKI 1971, and other authors <i>F. transcaucasica</i> Nassonov, 1889, sensu COLLINGWOOD 1979, and other authors <i>Leptocephalus kaszabi</i> Pisarski, 1969 <i>Leptocephalus melleus</i> Forel, 1904 <i>Leptocephalus melleus csikii</i> Pisarski, 1969 <i>Leptocephalus mongolicus</i> Pisarski, 1969 <i>Leptocephalus servicus mongolicus</i> Pisarski, 1969 <i>Leptocephalus nassanovi</i> Ruzsky, 1895 <i>Leptocephalus servicus</i> Ruzsky, 1902 <i>Tetramorium annectens</i> Pisarski, 1969 <i>Tetramorium jacoti</i> Wheeler, 1927
<i>Temnothorax kaszabi</i> (Pisarski, 1969)	
<i>Temnothorax melleus</i> (Forel, 1904)	
<i>Temnothorax mongolicus</i> (Pisarski, 1969)	
<i>Temnothorax nassanovi</i> (Ruzsky, 1895)	
<i>Temnothorax servicus</i> (Ruzsky, 1902)	
<i>Tetramorium tsushimae</i> Emery, 1925	

In several cases the names of the species have been changed since that time when DLUSSKY and PISARSKI identified the ant species from KASZAB's rich collection of the Mongolian fauna. For example *Formica manchii* Wheeler, 1929 was formerly named *F. longiceps* Dlussky, 1964 or *F. dlusskyi* Bolton, 1995 (see SEIFERT 2000) or *T. tsushima* Emery, 1925 formerly considered as *Tetramorium annectens* Pisarski, 1969 or *Tetramorium jacoti* Wheeler, 1927 (see BOLTON 1995). In the case of *Formica candida* Smith, 1878 this ant taxon was divided into two different species with separate zoogeography (SEIFERT 2004): the western "Black Bog Ant" redescribed as *Formica picea* Nylander, 1846, and *F. candida*, which is found in East Siberia from the eastern Altai mountains up to the Russian Far East, in Tibet, Mongolia, and North Korea. With these redescriptions the older name *Formica transcaucasica* Nassonov, 1889 that has been used for *F. candida*, e.g., in PFEIFFER et al. (2003), is invalid. Similarly some species of the genus *Leptocephalus* have been transferred to the genus *Temnothorax* (e.g., *Temnothorax mongolicus* (Pisarski, 1969) or *Temnothorax nassanovi* (Ruzsky, 1895) (BOLTON 2003). We excluded all synonymies (see Table 2) from the list.

4. DISCUSSION

For the first time we present a critical, tentative species list of the Mongolian Formicidae that includes all previously recorded taxa. We also added six new species, *F. pressilabris*, *L. gebaneri*, *M. commarginata*, *M. eidmanni*, *M. kamtschatica* and *M. taediosa* to the ant species list of Mongolia. Up to now the genus *Formica* provides the highest number of species (18) in this list, while *Myrmica* is represented by 14, *Lasius*, *Proformica* and *Temnotho-*

rax by five species, each. The large number of *Formica* and *Myrmica* ants, that dominate the northern parts of Mongolia, may be a hint towards the higher productivity of these regions (forest, steppe) compared to the semi deserts and deserts in the southern country. However, the study of the Mongolian Formicidae is still going on, and we are expecting that more species will be added to the list within the next years (e.g., social parasitic ants), because of new collections and/or changes in the taxonomic system.

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